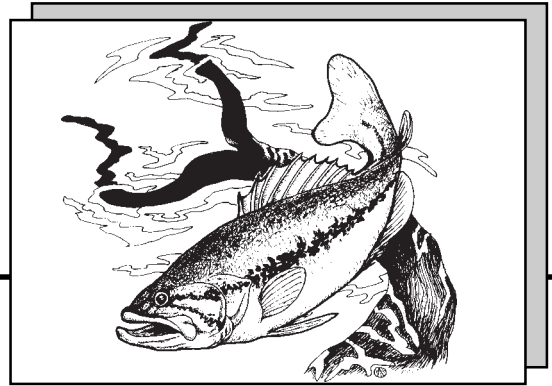


FHR

Currents...

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Direct Observations of Largemouth and Smallmouth Bass in Response to Various Brush Structure Designs in Ruth Reservoir, California

by Gregory J. Bryant

Abstract

The purpose of this study was to evaluate the effectiveness of three brush structure designs as spawning cover and rearing habitat for largemouth and smallmouth basses, and to observe the interaction of all species around the structures compared to natural habitat locations. Comparisons of habitat utilization by young-of-year, juvenile, and adult largemouth and smallmouth basses were made between control sites, structures, and between sampling dates within and between each cove. The use of the brush structures and control sites were evaluated by two divers using SCUBA. Adult basses were occasionally observed in habitats located towards the back of coves; however, after spawning, adult basses utilized rocky point habitats and brush structures located near the entrances of coves adjacent to deep water channels, through the summer and fall in 1989 and 1990. As water temperatures increased and water levels remained constant through the spring and fall, juvenile

basses were found to utilize backwater areas and structures located towards the back of coves. When water temperatures and levels decreased rapidly, juvenile basses migrated out of shoreline habitats to brush structures and control sites located towards the entrances of coves in deeper water. Young-of-year basses were found to utilize backwater area habitats and brush structures located towards the back of coves. As the number of juvenile basses increased in backwater areas, young-of-year basses migrated towards brush structures located near the entrances of coves. The discrete open center structure was the most utilized of the three designs by young-of-year, juvenile, and adult largemouth and smallmouth basses in 1989 and 1990. However, both the continuous open center and dense design structures were utilized by largemouth and smallmouth basses more than shoreline areas with no aquatic vegetation or woody debris. Water temperature, water level, brush structure location, and brush structure design were found to be the most important physical factors influencing habitat utilization by both largemouth and smallmouth basses in Ruth Reservoir.



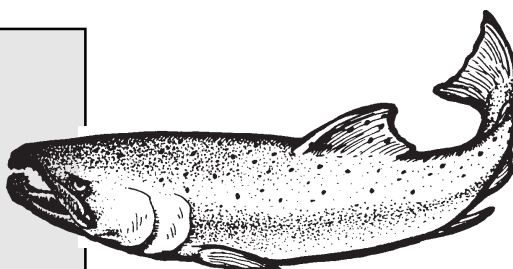
USDA
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FHR Currents... **Purpose**

The Fish Habitat Relationship (FHR) Program of Region 5, Pacific Southwest Region, USFS has been established to research and develop information on fish ecology and to coordinate effective applications of this knowledge in managing and protecting our fisheries. By relating life state requirements of specific species to physical habitat parameters, we are aiming at our main objective: developing a methodology to manage fisheries through the management of habitat.

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Introduction

Largemouth bass (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*) are two of the principle warm water predators in lakes and reservoirs. They are often found in open water areas, but are usually associated with shoreline cover or deep water structures (Vogele and Rainwater 1975; Warden and Lario 1975; Savitz et al. 1983). Largemouth bass, the most common black bass species in California, are native to the eastern part of the United States. It is primarily a fish of lakes, ponds, oxbows, and the quieter portions of flowing water (Robbins and MacCrimmon 1974). They grow best in clear water with aquatic vegetation; the adults prefer areas with abundant macrocover such as stumps, dead trees, tree roots, or large rocks (Aggus and Elliot 1975; Morgenson 1983). Smallmouth bass also are native to the eastern United States. Smallmouth bass prefer clear-water lakes and cool streams with moderate current, and rock and gravel substrate (Robbins and MacCrimmon 1974). In lakes and reservoirs, smallmouth bass live in rocky-rubble sites and areas with stumps and vegetation (Forney 1972; Pflug and Pauley 1984; Kraai and Munger 1991).

The magnitude of water level fluctuations in reservoirs resulting from irrigation, hydro-electric generation, industrial, and municipal needs often precludes the establishment of a suitable and stable littoral zone in the form of rooted aquatic vegetation (Brouha and Von Geldern 1979). In addition, several other physical conditions such as turbidity, shoreline erosion, poor soils, and steep sideslopes further inhibit rooted aquatic growth. As a reservoir ages, terrestrial vegetation in newly flooded basins which help stabilize the shoreline and provide spawning and nursery habitat for warm water fish, is gradually lost. The loss of these materials is believed to be responsible, in part, for the observed declines in production of

certain littorally-oriented species such as largemouth and smallmouth basses which are heavily dependent on stable and sheltered shorelines (Von Geldern 1971; Forney 1972; Aggus and Elliot 1975; Wege and Anderson 1979; Stuber et al. 1982; Ploskey 1982; Morgenson 1983; Anderson 1984; Durocher et al. 1984).

In an effort to provide adequate spawning, rearing, and cover habitat in littoral zones, habitat enhancement structures have been used extensively in the eastern and southern portions of the United States (Rodeheffer 1939, 1940, 1945; Sheridan 1957; Thomas et al. 1968; Crumpton and Wilbur 1973; Prince and Brouha 1973; Brouha 1974; Prince et al. 1975; Majure 1977; Prince and Maughan 1977; Reeves et al. 1977; Pierce and Hooper 1979; Smith et al. 1980; Hasse 1986; Hoff 1991) and now have become an important fishery management tool in the west (Bartholomew 1972; Pollard 1974; Vogel and Rainwater 1975; Brouha and Von Geldern 1979; Fitch 1982; Larson et al. 1986; Warnecke and McMahon 1988; Cross 1989; Lee and Gleason 1989; Christenson 1990; Cofer 1991; Mabbot 1991; Uberuaga and Bizios 1991). However, there has been very little information presented on the seasonal utilization and intraspecific behavior of bass associated with brush structures versus natural habitats within fluctuating reservoirs and lakes.

The purpose of this study was to evaluate the effectiveness of three specific brush structure designs as spawning cover and as rearing habitat for largemouth and smallmouth basses compared to natural habitat locations. In addition, the interaction of all species around the structures compared to natural habitat locations were observed.

Study Site

Ruth Reservoir is impounded behind R. W. Matthews Dam (completed in 1961), at the headwaters of the Mad River in Trinity County, California. This water supply reservoir, about 127 river kilometers (79 river miles) from the Pacific Ocean, provides municipal and industrial water for the Humboldt Bay area. The reservoir is 11 kilometers (17 miles) long, has a mean width of 0.6 kilometers (0.4 miles), a maximum surface area of 445 hectares (1100 acres), a maximum storage capacity of 64 million meters³ (2.2 billion feet³), and a mean depth of 14.4 meters (47 feet) at maximum pool. Water level fluctuates about 10 meters (33 feet) annually and is lowest in fall and highest in winter and spring.

Methods

Eight manzanita (*Arctostaphylos manzanita*) brush structures of three designs (dense, discrete open center, and continuous open center (Figure 1) were placed in selected areas in the

reservoir during low water in fall of 1988. Each structure was 35 meters (115 feet) long, 3 meters (10 feet) high, and 4 meters (13 feet) wide. Structures were cabled together with 0.32 centimeters (0.12 inches) diameter wire, and weighted with cement blocks every 2 meters (7 feet). Single structures of each design was placed in two coves and two discrete open center structures were placed in a third cove (figure 2).

Nine control sites were established in spring 1989 and were representative of three basic habitat types: rocky points (substrate consisting of large rocks or boulders located adjacent to deep water), backwater areas (substrate consisting of silt, sand and/or gravel located towards the back of coves), or shorelines with aquatic vegetation (substrate consisting of silt, sand, and/or gravel located throughout the reservoir). Five control sites were in coves with brush structures, one in a fourth cove and three in the open reservoir (one at north end, middle, and south end). Each control site was 35 meters (115 feet) long and 4 meters (13 feet) wide.

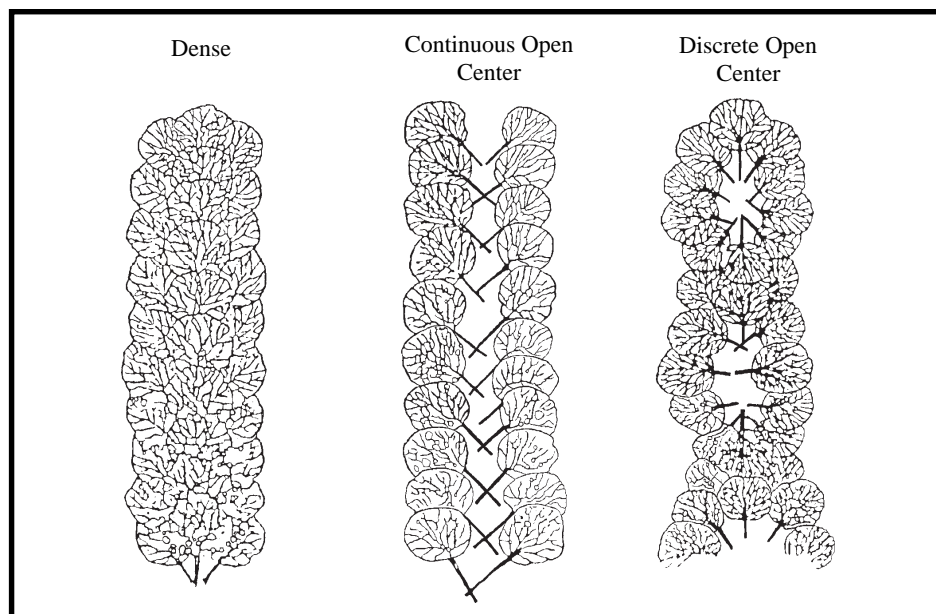


Figure 1. Brush structure designs for Ruth Reservoir, Trinity County, California

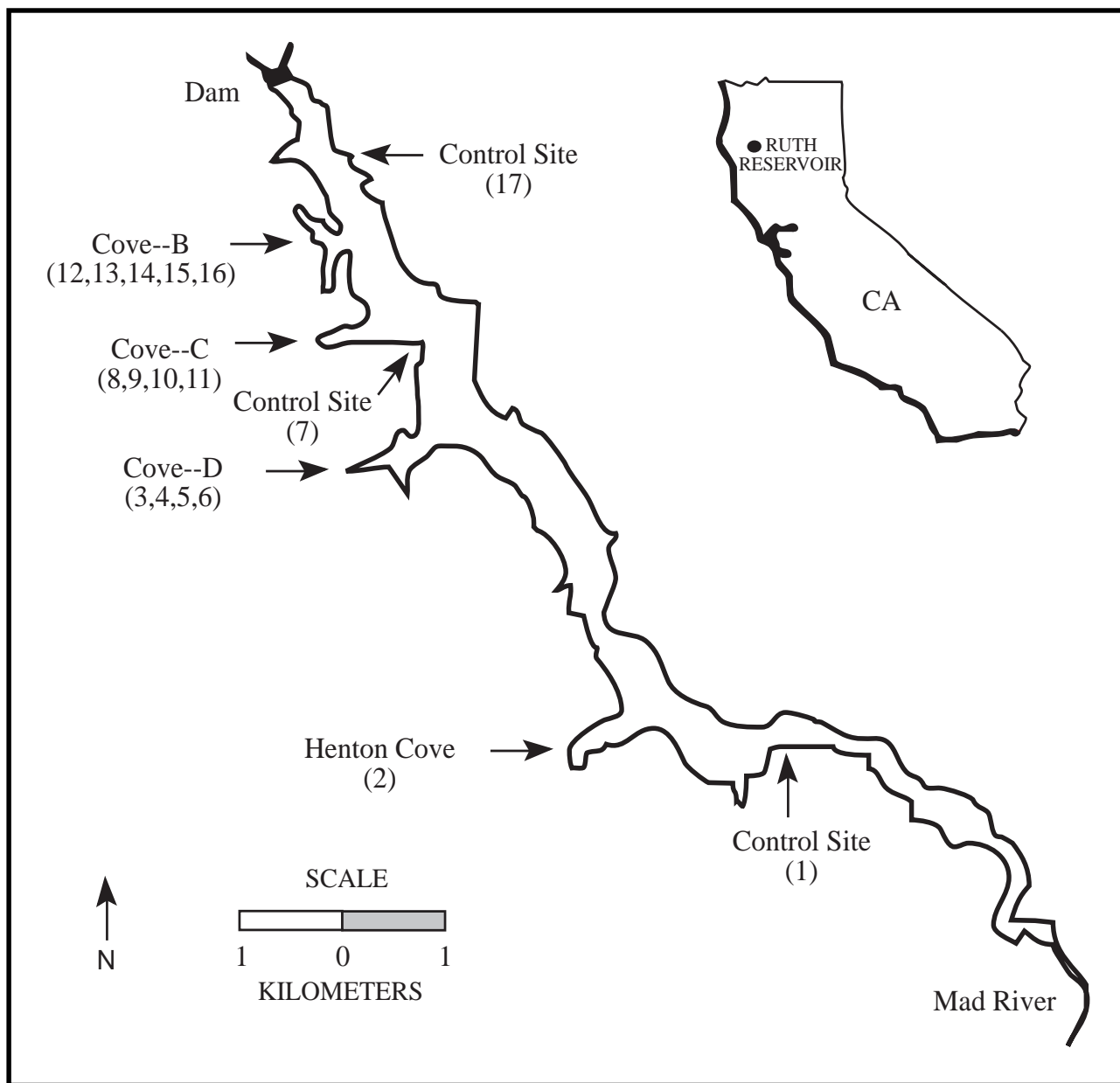


Figure 2. Transect locations in Ruth Reservoir, Trinity County, California

Transects were established at the eight brush structures and nine control sites. All transects were perpendicular to the shoreline. Two wire baskets 25.4 centimeters (10 inches) x 12.7 centimeters (5 inches) x 7.6 centimeters (3 inches) filled with gravel were placed at the deep-water corners of all transects to mark deep water transect boundaries.

Physical descriptions of transects were observed and recorded using the following criteria: structure type or control site habitat type, percent slope (gradual 0-10 percent, moderate 11-40 percent, steep >40 percent), general abundance of vegetation and naturally occurring woody debris (absent 0 percent, spotty 1-10 percent, moderate 11-40 percent, heavy >40 percent) (Table 1). Percent slope was measured with a clinometer at low water level in the fall of 1989.

Transect ^a		Description
1	Upper Reservoir	Control site, rocky point, moderate vegetation, steep slope
2	Henton Cove	Control site, backwater channel, moderate vegetation, gradual slope
3	Cove D	Control site, rocky point, absent vegetation, steep slope
4	Cove D	Subcove 1, control site, spotty vegetation, gradual slope
5	Cove D	Subcove 2, discrete open center structure, spotty vegetation, gradual slope
6	Cove D	Open cove, discrete open center structure, spotty vegetation, moderate slope
7	Mid Reservoir	Control site, rocky point, absent vegetation, steep slope
8	Cove C	Dense structure, absent vegetation, moderate slope
9	Cove C	Discrete open center structure, absent vegetation, moderate slope
10	Cove C	Continuous open center structure, absent vegetation, moderate slope
11	Cove C	Control site, backwater channel, spotty vegetation, moderate woody debris, gradual slope
12	Cove B	Dense structure, spotty vegetation, moderate slope
13	Cove B	Control site, moderate vegetation, moderate slope
14	Cove B	Continuous open center structure, spotty vegetation, moderate slope
15	Cove B	Control site, backwater channel, heavy vegetation, heavy woody debris, gradual slope
16	Cove B	Discrete open center structure, spotty vegetation, moderate slope
17	Lower Reservoir	Control site, rocky point, absent vegetation, moderate slope
^a See Figure 2 for transect locations		

Table 1. Description of transects for direct observations in Ruth Reservoir, Trinity County, California.

The use of the brush structures and control sites were evaluated by two divers using SCUBA (Bryant, in press). The sites were sampled every other week from July through September in 1989 and 1990. Comparisons of habitat utilization by young-of-year <5.0 centimeters (<2 inches), juvenile 5.0-20.5 centimeters (2-8 inches) and adult >20.5 centimeters (>8 inches) largemouth and smallmouth basses were made between control sites, structures, and between sampling dates within each cove and between the coves for each size group of bass.

Data were analyzed separately each year using Friedman's test (Zar 1984). If Friedman's test

indicated a significant difference ($P \leq 5$ percent), then it was followed with a non-parametric multiple comparisons test (Wilcoxon and Wilcox 1964). To eliminate repetition, the term "bass" or "basses" as used in this paper will include both species unless otherwise stated.

Results and Discussion

Young-of-Year Basses:

Total number of observed young-of-year basses increased across all transects from 1989 to 1990 (figure 3). This increase of young-of-year basses

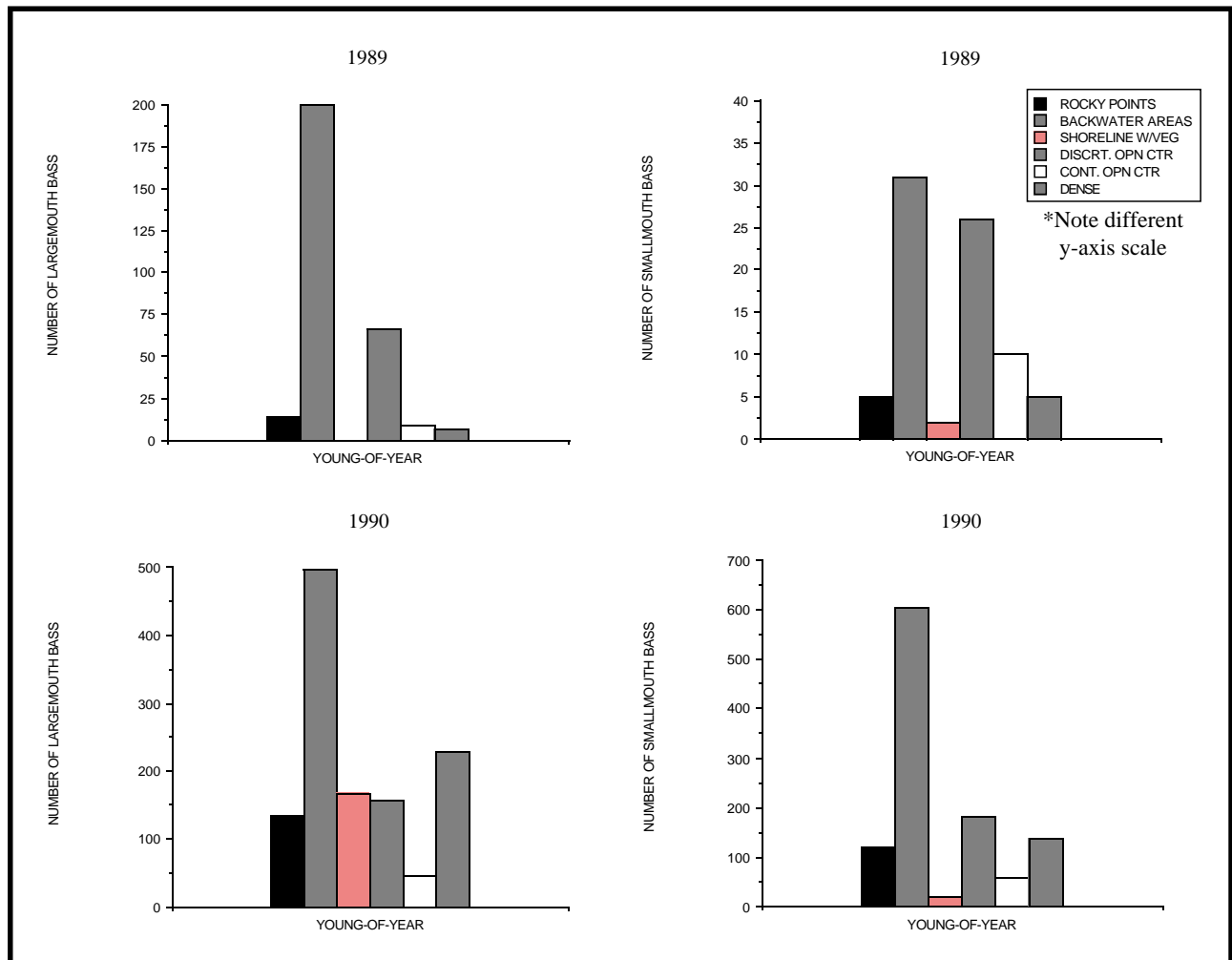


Figure 3. Total number of young of year largemouth and smallmouth basses observed by habitat type in Ruth Reservoir, Trinity County, CA 1989 and 1990.

was possibly due to a more successful spawning season in 1990 as was indicated by spawning surveys (Reck , in preparation).

Previous studies have reported that large numbers of young-of-year centrarchid basses utilized artificial structures for shelter (La Roche 1972; Prince and Brouha 1973; and Pollard 1974). The structures in Ruth Reservoir did serve as shelters for both young-of-year bass species in the summer of 1989 and 1990. In 1989 young-of-year bass were more frequently observed utilizing the discrete open center structures located towards the back of coves; however, in 1990 both the discrete open center and dense design structures were equally utilized. As the water level in Ruth Reservoir was drawn down and the numbers of juvenile fish increased in backwater locations, young-of-year basses were found to utilize shoreline areas of the dense design structures located towards the entrances of coves. The majority of the aquatic macrophyte beds located in backwater areas had been dewatered by September, and the dense design structures offered the most cover and an abundant source of invertebrate prey for young-of-year basses.

Backwater area control sites consistently had higher numbers of young-of-year basses than all other transect locations. These areas typically were shallower in slope, warmer, the most protected from the wind, and usually had a dense to moderate growth of aquatic macrophytes. There were also tremendous numbers of aquatic invertebrates in the backwater areas, and the aquatic macrophytes (primarily *Potamogeton pusillus*; *P. nodosus*; and *P. amplifolius*) supplied the thickest cover for young-of-year bass. Okeyo and Hassler (1985) found that aquatic invertebrates made up the largest part of the diet of young bass in Clair Engle Lake, California.

Young-of-year basses seemed to have been migratory from the time they left the nest through dispersion into the available shoreline habitats in Ruth Reservoir in both years. Several schools of mixed young-of-year largemouth and smallmouth basses, with either an adult largemouth or smallmouth bass in attendance, were observed moving into brush structured transects each year. After only one day on the structures, the schools of integrated young-of-year basses dispersed along the shoreline edge into mats of aquatic vegetation, and the adult departed. Exchange of fish schools between adjacent coves and migration into shallow waters occurred frequently in Ruth Reservoir. Allan and Romero (1975) found similar results in their study which reported that inventories of bass fingerling populations were severely complicated in defined study areas as a result of lateral and vertical dispersion which progressed through the summer months. In Ruth Reservoir, when young-of-year bass were found, they were in mixed schools of largemouth and smallmouth bass, black crappie (*Pomoxis nigromaculatus*), golden shiner (*Notemigonus crysoleucas*), bluegill (*Lepomis macrochirus*), and green sunfish (*Lepomis cyanellus*).

Juvenile Basses:

Juveniles represented the majority of total bass observed throughout all transect locations in 1989 and 1990 (figure 4). However, their numbers decreased from 1989 to 1990 across all transect types. A decrease in juvenile bass numbers in 1990 surveys could have been due to larger juvenile bass in 1989 surveys growing to the adult size classification in 1990 surveys and low recruitment of young-of-year bass from 1989 surveys.

Juvenile bass more frequently utilized the discrete open center design structures than the

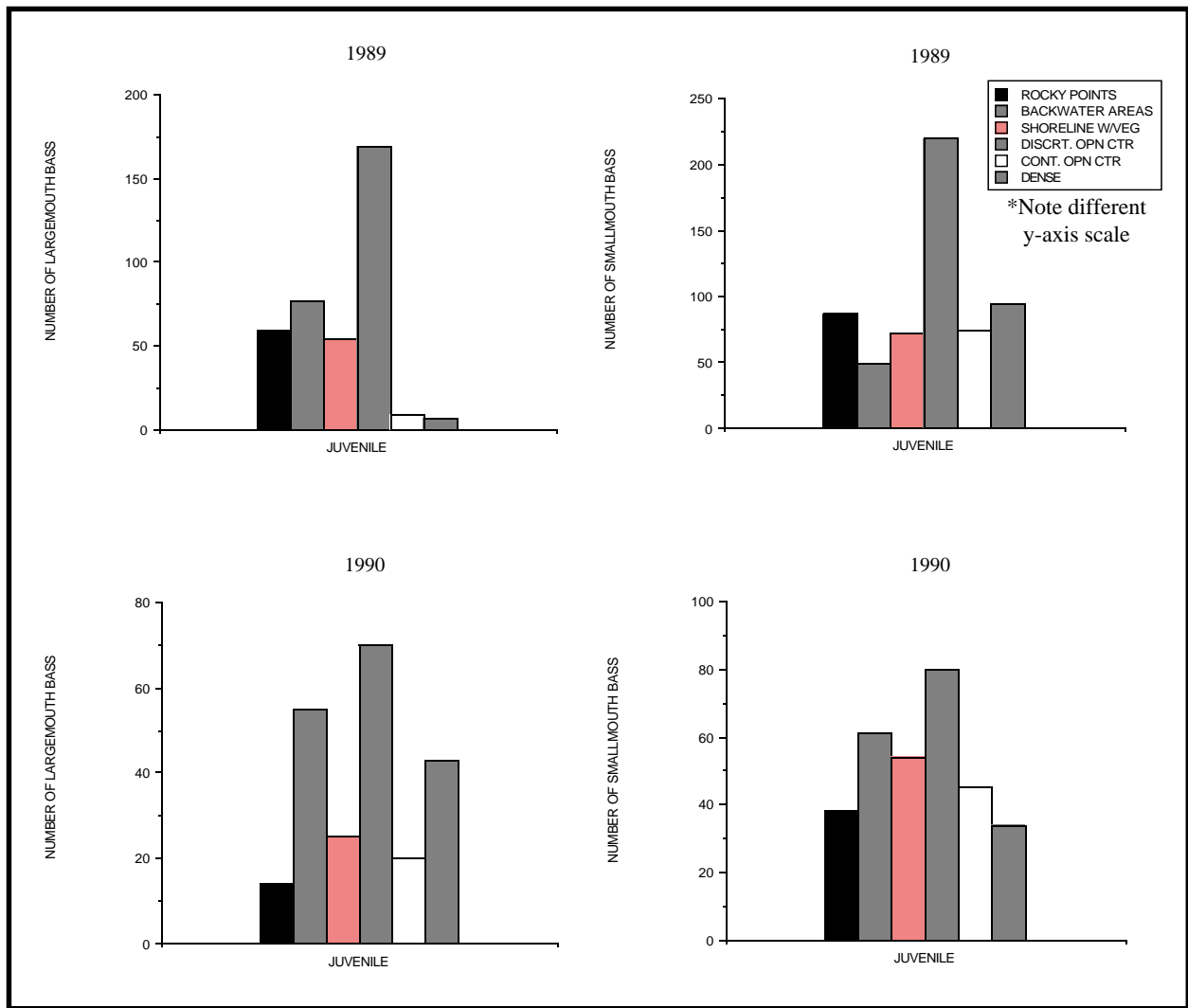


Figure 4. Total number of juvenile largemouth and smallmouth basses observed by habitat type in Ruth Reservoir, Trinity County, CA 1989 and 1990.

continuous open center and dense design structures. Higher numbers of juvenile smallmouth bass were observed on the structures in 1989 than largemouth bass juveniles, but each were equally represented in 1990.

Backwater control sites were the most frequently utilized control site type for both species of juvenile bass in both years. In 1989 and 1990, rocky points and shoreline areas with spotty to moderate amounts of aquatic macrophytes were equally utilized habitats by both species of juvenile bass.

Juvenile bass numbers increased in backwater control sites and structure sites as the season progressed and water temperatures exceeded 22 C (71 F), peaking in late July for largemouth bass, and August and September for smallmouth bass. Juvenile bass numbers remained fairly constant in these locations through most of the season as long as water levels and temperatures remained steady. Juvenile bass were predominantly found within 1.0 meter (3 feet) of the water's surface in backwater channels and structures during mid-summer, and then were

found 3-8 meters (10-26 feet) deep as they migrated vertically from shoreline habitats when water temperatures dropped more than 2 C (3.5 F) in August and September of 1989 and 1990. Rodeheffer (1945), who compared fish utilization of brush structures located at depths of 1.5, 3.0, and 4.6 meters (5, 10, and 15 feet), found that during July and August, juvenile bass preferred structures in shallow water at the 1.5 meters (5 feet) level. Prince and Brouha (1973) reported that immature bass were found in greatest numbers on structures located in shallow water during summer months

in Smith Mountain Lake, Virginia. In Ruth Reservoir, shallow water habitats that were warmer, protected from the wind, had higher concentrations of potential prey species, and offered cover in the form of brush structures or aquatic macrophytes adjacent to deeper water were the most selected locations by both species of juvenile bass.

Adult Basses:

Total number of adult basses observed increased from 1989 to 1990 across all transect

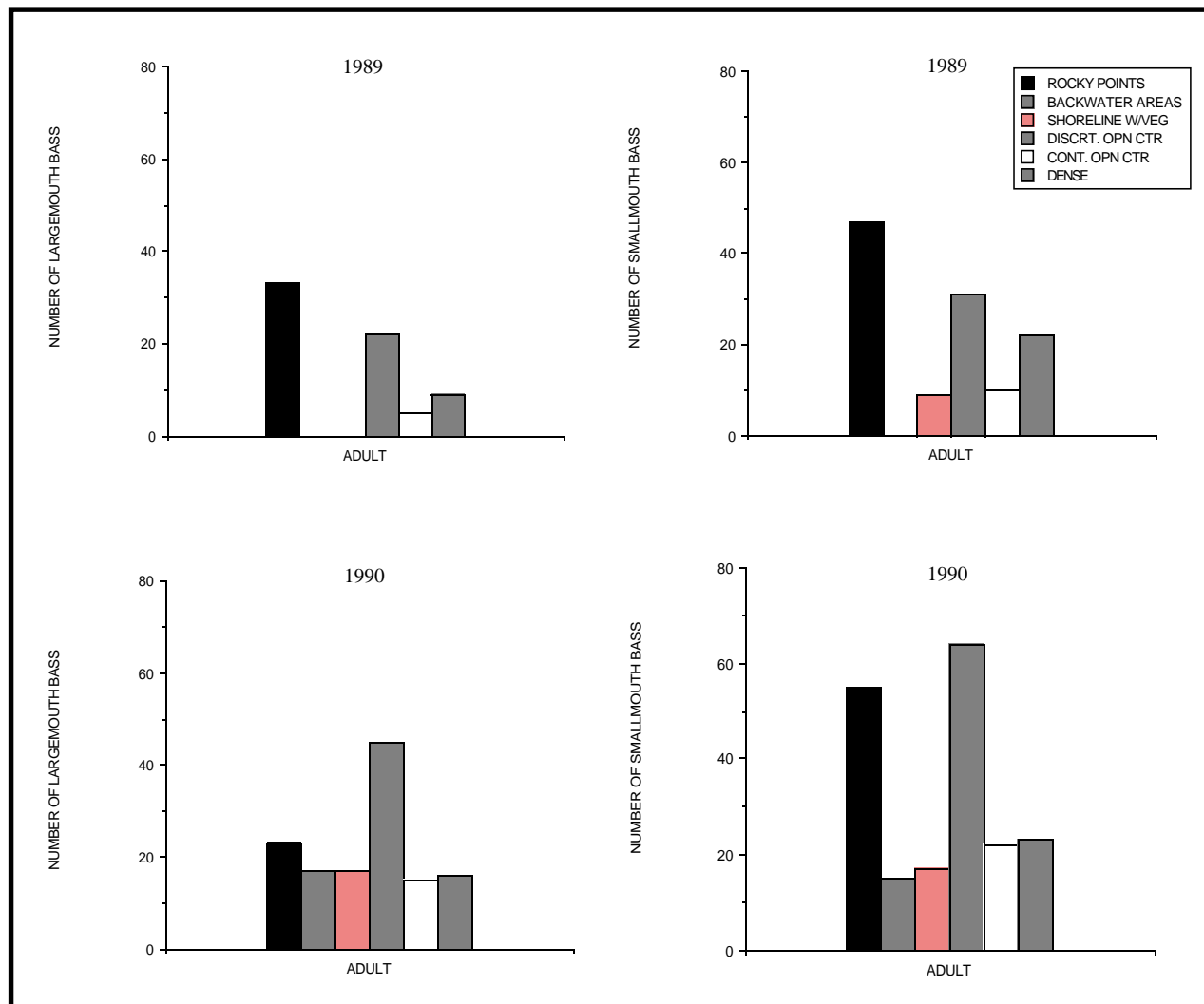


Figure 5. Total number of adult largemouth and smallmouth basses observed by habitat type in Ruth Reservoir, Trinity County, CA 1989 and 1990.

types (Figure 5). This increased number of adult bass could be attributed to the recruitment of 1989's larger juveniles into the adult size category for 1990 surveys which was mentioned previously.

The discrete open center structure was the most utilized structure design for both species of adult bass throughout the study. Largemouth bass adults primarily concentrated on the structures April through May in 1989 and 1990. Smallmouth bass adults utilized all structures more than the adult largemouth bass throughout the study each year. This could have been an artifact of natural segregation of largemouth and smallmouth bass within Ruth Reservoir. The south end of the reservoir was typically shallower and had the majority of aquatic macrophyte beds; whereas, the north end was typically steeper and had very limited areas of aquatic macrophyte beds.

Rocky points were the most inhabited control site type throughout the reservoir by both adult bass species in Ruth Reservoir. Rocky points offered adult basses deep water escape routes and excellent feeding areas among the rocks. As the seasons progressed from spring to fall and the water level dropped, greater numbers of adult bass species were found to utilize rocky points.

The structures in Ruth Reservoir attracted pre-spawning adult basses in 1989 and 1990 as water temperatures exceeded 13 C (55 F). Largemouth bass grouped together at the shallow end of structures, in less than 1.6 meters (5 feet) of water, and smallmouth bass were spread throughout the structures from 1.0-4.5 meters (3-15 feet) of water. In Ruth Reservoir the structures seemed to be a grouping area for adult bass to gather and begin their courtship behavior; however, only two largemouth bass nests were found near brush structures each year. La Roche (1972) found that large-

mouth bass and pumpkinseed sunfish (*Lepomis gibbosus*) spawned in the vicinity of brush structures in Sand Pond, Maine. Vogele and Rainwater (1975) reported that spotted bass (*Micropterus punctulatus*) and largemouth bass in Bull Shoals Reservoir selected areas adjacent to brush shelters as spawning sites, but that smallmouth bass did not. As water temperatures approached 20 C (68 F) in Ruth Reservoir, there was an increase in numbers of golden shiners, green sunfish, and juvenile basses in shallow water transects in less than 3 meters (10 feet) of water. Because of the increased numbers of fish species in transect locations, adult bass may have been forced to select nesting locations in areas less disturbed by potential predators.

As the water warmed to 20 C (68 F) in Ruth Reservoir, most adult bass began to move away from the structures and were observed roaming the shoreline within all coves, possibly looking for spawning companions. Once spawning behavior began, the numbers of adult largemouth bass remained low on the structures and backwater areas throughout the season for both years. Adult bass were occasionally observed in habitats located towards the back of coves. However, after spawning, adult basses utilized rocky point habitats and brush structures located near the entrances of coves, adjacent to deep water channels, through the summer and fall in 1989 and 1990. The few adult bass observed on the structures after spawning were usually located in the middle and deeper ends of the structures, preferring 3 meters (10 feet) of water depth and deeper. They normally were solitary and were located within the inside and outside edges of the structures. Shoreline areas devoid of structures, backwater areas, and structures located towards the back of coves were generally not utilized by the adult basses after spawning.

Other Benefits of Brush Structures:

In other studies, biologists have reported increased production in plant and animal populations associated with artificial structures. Tarzwell (1936) reported that algae, crayfish, and aquatic insects were more abundant in brush shelter areas than in non-shelter areas of Douglas Lake, Michigan. Thomas and Bromley (1968), who evaluated the same brush shelters 30 years later, found that those structures contributed to the establishment of rooted aquatic vegetation and algae. Chafin (1968) observed large numbers of aquatic invertebrates, mostly midge larvae, associated with periphyton on submerged trees in two Missouri River reservoirs.

The structures in Ruth Reservoir were colonized by periphyton within the first year, and by 1990 long filamentous green algae covered all of the structures. Increased numbers of aquatic invertebrates associated with the structures were seen as well as increased sediment at the base of all the structures. The increase of sediment load around each structure was beneficial in many ways: it was an excellent base for aquatic macrophytes to root, decreased shoreline erosion, and the structures decreased the wave energy impacting the shoreline. Consequently, aquatic macrophytes became well established within the boundaries and adjacent to the leeward side of the structures.

Conclusions

Behavior of basses associated with artificial structures has not been well studied or documented. Direct observations at Ruth Reservoir are far from conclusive, but generally support the thesis of seasonally localized bass stocks associated with structured areas.

Although artificial structures are not a panacea for every bass management problem, the results show that such structures can indeed benefit the bass fishery in shelter-deficient lakes and reservoirs. With a better understanding of habitat utilization by specific age classes of fish, and the seasonal variations associated with habitat use, fishery managers will have greater success with the proper design, placement, and monitoring of structures. Furthermore, by understanding lateral and vertical migration patterns of fishes in reservoirs and lakes as it relates to fluctuating water levels and water temperatures, fishery managers can develop a more comprehensive habitat enhancement program directed towards specific age classes of fish under varying conditions.

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